Electric Motor Thermal Management

June 21–23, 2022 – Project ID: ELT214

PI: Kevin Bennion (National Renewable Energy Laboratory); **Team:** Emily Cousineau, Doug DeVoto, Xuhui Feng, Bidzina Kekelia, Jeff Tomerlin (NREL); Mostak Mohammad (ORNL); Iver Anderson (Ames Laboratory); Todd Monson (SNL); Yogendra Joshi, Satish Kumar (Georgia Institute of Technology); Bulent Sarlioglu, Thomas Jahns (University of Wisconsin-Madison)

OVERVIEW

Timeline

- Project start date: October 2018
- Project end date: September 2024
- Percent complete: 70%

Budget

- Total project funding: $1,000,000
- U.S. Department of Energy (DOE) share: $1,000,000
- Funding for FY 2021: $250,000
- Funding for FY 2022: $250,000

Barriers addressed

- Cost, power density, and lifetime.

RELEVANCE

This project is part of the Electric Drive Technologies (EDT) Consortium and focuses on NREL's role under Keystone 2. The research enables compact, reliable, and efficient electric machines

- Motor 10x power density increase (2025 versus 2015 targets) [1]
- Motor 2x increase in lifetime [1]
- Motor 53% cost reduction (2025 versus 2015 targets) [1]

[1] U.S. DRIVE. 2017. *Electrical and Electronics Technical Team Roadmap*. https://www.energy.gov/sites/default/files/2017/11/f39/EETT%20Roadmap%2010-27-17.pdf

ACKNOWLEDGMENTS

Susan Rogers, U.S. Department of Energy

For more information, contact:

NREL EDT Task Leader

Sreekant Narumanchi

Sreekant.Narumanchi@nrel.gov

Phone: 303-275-4062

NREL Principal Investigator

Kevin Bennion

Kevin.Bennion@nrel.gov

Phone: 303-275-4447

APPROACH

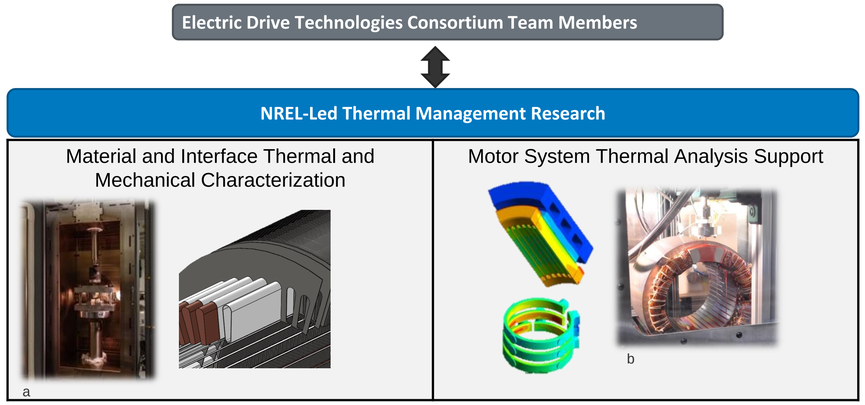
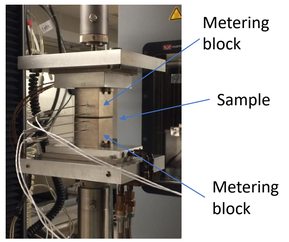


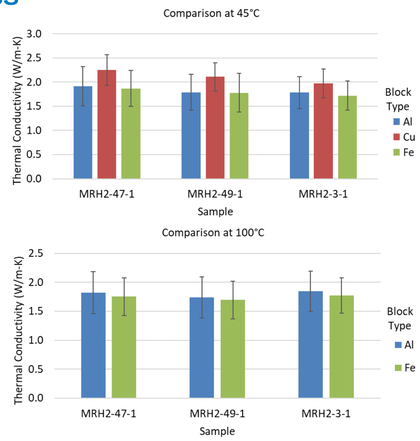
Photo credits:
a: Doug DeVoto, NREL
b: Kevin Bennion, NREL

ACCOMPLISHMENTS AND PROGRESS

Collaboration with Sandia National Laboratories (ELT216)

- Completed measurements of new motor materials with multiple metering block materials for experimental setup showing no change in results within 95th percentile confidence interval.

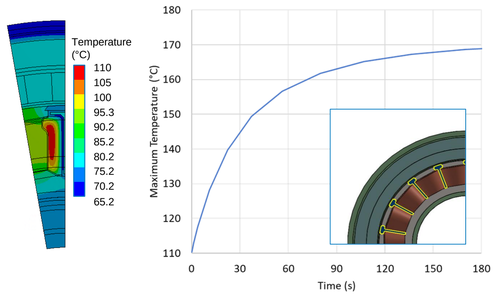




Sample from SNL undergoing thermal measurement. Photo by Emily Cousineau, NREL (left). Comparison of different metering block materials showing consistency of measured thermal conductivity within shown 95th percentile confidence intervals at two evaluated temperatures (right).

Collaboration with Oak Ridge National Laboratory (ELT212)

- Thermal design shown to meet 30-second peak power temperature requirement.



Steady-state temperatures at 6,667 RPM and 62.2 kW (left). Transient temperature response at peak power operating point from steady-state showing ability to operate over 30 seconds before reaching 150˚C temperature limit (right).

COLLABORATION AND COORDINATION

Material and Interface Thermal and Mechanical Characterization

- Collaboration with **Sandia National Laboratories** (ELT216) to support mechanical and thermal measurements of new motor materials.
- Collaboration with **Ames Laboratory** (ELT215, ELT234) to support thermal analysis of electric machines enabled by material innovations.

Motor System Thermal Analysis Support

- Collaboration with **University of Wisconsin** (ELT243), with NREL providing technical support, thermal data, and material information to support integrated cooling of motor and power electronics.
- Collaboration with **Georgia Institute of Technology** (ELT251), with NREL providing technical support, geometry data, thermal modeling data, and NREL laboratory access to students for evaluations of advanced cooling impacts.
- Collaboration with **Oak Ridge National Laboratory** to support motor thermal analysis and thermal design of advanced machine design led by ORNL (ELT212).
- Collaboration with Keystone 3 project areas at ORNL (ELT221) and NREL (ELT217).

FUTURE WORK

- In collaboration with ORNL, build prototype heat exchanger to verify expected cooling performance in relation to the non-heavy-rare-earth, high-speed motors research effort led by ORNL.
- In support of SNL, prepare for mechanical property tests of additional SNL material samples.
- Support Georgia Institute of Technology in efforts to model motor thermal management concepts, conduct experiments, and publish motor thermal management research results.
- Continue meetings and discussions with University of Wisconsin-Madison to provide technical support, thermal data, and material information to support integrated cooling of motor and power electronics.

Any proposed future work is subject to change based on funding levels.

SUMMARY

Approach/Strategy

- Supports research enabling compact, reliable, low-cost, and efficient electric machines aligned with roadmap research areas [1].
- Collaborate with ORNL, Ames, and SNL to provide motor thermal analysis support, reliability evaluation, and material measurements on related motor research at national laboratories.
- Collaborate with university partners including Georgia Institute of Technology and University of Wisconsin-Madison to support university-led motor thermal management and development research efforts.

Technical Accomplishments

- NREL collaborating with SNL to support mechanical and thermal measurements of new motor materials.
- NREL providing thermal design support for electric machine design process led by ORNL.

Collaborations

- Oak Ridge National Laboratory (ORNL)
- Ames Laboratory
- Sandia National Laboratories (SNL)
- Georgia Institute of Technology
- University of Wisconsin-Madison

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy's Vehicle Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.